Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

United States Department of Agriculture,

OFFICE OF EXPERIMENT STATIONS—CIRCULAR 77 (Revised).

A. C. True, Director.

A SECONDARY COURSE IN AGRONOMY.[a]

Since your committee four years ago reported on secondary courses in agriculture interest in instruction in courses below college grade has continued to increase, and the demand for a definite programme for use in high schools has become insistent. The committee has considered it wise to undertake to meet this important demand.

In its former report[b] a number of tentative schedules for high school courses were presented to show the place of agriculture in such courses and to show that agricultural courses may be offered in the schools without any violent or radical reorganization of existing programmes for such schools. The committee dealt with the schedule of the ordinary high school, and not that of special agricultural high schools or other forms of secondary agricultural schools. In the syllabus and the outline of lectures, demonstrations, laboratory exercises, and recitations which are submitted in this report it is assumed that agriculture will be related to the high school course as a whole, as will Latin, algebra, chemistry, physics, botany, or any other subject of study.

The probable and possible teaching force, the facilities of instruction, and the exigencies of a high school schedule have been carefully considered. The committee has deemed it more important to outline a course of study that can be used by the high schools than to have it at all points pedagogically consistent. In preparing this outline the committee has availed itself of the services of a graduate of both a scientific and an agricultural course, who has had several years' experience in high school instruction.[c]

The term agriculture as applied to courses of instruction should be used to include in a comprehensive way the science and practice of the production of plants and animals useful to man and the uses of such plants and animals as far as these are closely connected with their production. Agriculture may be divided into (1) plant production, (2) animal production or zootechny, (3) agrotechny or agricultural technology, (4) rural engineering, and (5) rural economics.

[a] This is the Eleventh Report of the Committee on Instruction in Agriculture of the Association of American Agricultural Colleges and Experiment Stations.

[b] Seventh Report of the Committee on Methods of Teaching Agriculture, U. S. Dept. Agr., Office of Experiment Stations Circ. 49.

[c] Dr. G. F. Warren, assistant professor of agronomy, Cornell University.

Plant production includes whatever relates to the natural or artificial environment (i. e., climate, soil, water, fertilizers, etc.) of useful plants, their structure, composition, physiology, botanical relations, varieties, geographical distribution, culture, harvesting, preservation and uses, and the obstructions to their growth, preservation, or use. Plant production may be subdivided into Agronomy, which deals with what are commonly called field or farm crops; Horticulture, which deals with vegetables, fruits, and ornamental plants; and Forestry, which deals with trees and shrubs grown in large tracts.

Animal production or zootechny includes whatever relates to the anatomy, physiology, zoological relations, domestication, types and breeds, breeding, feeding, hygiene, management, and uses of useful animals. It may also include diseases and other impediments to the production of animals, i. e., Veterinary Medicine.

Agrotechny includes whatever relates to the conversion of raw materials produced in agriculture into manufactured articles for use in commerce and the arts, as far as such manufacture is closely connected with agriculture, e. g., dairying and sugar-making.

Rural engineering includes those branches of civil and mechanical engineering which relate to the locating, arranging, and equipment of farms and plantations and the construction and operation of implements and machinery in agriculture. It embraces such subjects as roads, drains, irrigation, farm buildings, etc.

Rural economics is a somewhat elastic term, but includes at least whatever relates to the production, preservation, and distribution of wealth by the use of land for the growing of plants and animals. It may include the development of agriculture as a business (history of agriculture) as well as the facts and principles of farm management under present conditions.

In the minds of the committee, agricultural instruction in the high school may properly fall into two groups: Group I, agronomy, rural engineering, and rural economy; and Group II, zootechny and dairying. It is recommended that Group I, or agronomy, occupy the junior year, and Group II, or zootechny, occupy the senior year. It is the purpose, however, to have the outline of daily exercises sufficiently flexible to make it possible for high school authorities to adapt it to the exigencies of their schedules and also to permit emphasis being placed upon the forms of the industry most important to the immediate neighborhood of the school. Thus, if only one year can be given to the subject, certain exercises may be omitted to bring the instruction within the compass of the time allowed, and if the main industry is one requiring special emphasis being placed upon fertilizers or irrigation, or upon a particular crop, such as cotton, then

these subjects will be selected for fullest discussion, although not necessarily omitting entirely other subjects.

At this time a report is made upon the subject of agronomy, it being the purpose of the committee to make a similar report upon zootechny later. Strictly speaking, agronomy deals only with the theory and practice of the production of farm crops, including the study of climate, soils, fertilizers, and other matters closely related to crop production. In this report, however, the committee has thought it best to include a few lessons on horticulture and forestry in cases where publications and illustrative material are available for such study. This is done with a view of encouraging some attention to the growing of vegetables and fruits, the eradication of insect pests and diseases of plants, and the management of the wood lot on the ordinary farm. It is hoped and expected that in the near future the committee will be able to offer suggestions for more extended secondary courses in both horticulture and forestry. The course of study outlined in this circular is based upon the assumption that the study of agriculture will be preceded by botany, physiology, and, if possible, chemistry, and that the text-books used or the class of subjects discussed under each science will be those most important to a clear understanding of agronomical teaching.

SYLLABUS ON AGRONOMY FOR SECONDARY INSTRUCTION.

The following syllabus has been prepared not only to give the teacher the limits of the subject to be taught, but to present the point of view from which the subject should be taught. A Japanese scholar, while speaking before an American audience recently, remarked: "I noticed one very marked difference in the agriculture of Europe and America from that of Japan. In Europe and America you work the soil; in Japan we are interested in growing crops." This syllabus has been prepared from the Japanese point of view, namely, that the aim in agronomy is the production of plants useful to mankind, a definition this committee gave to agronomy in its third report in 1898.

In this syllabus emphasis is not placed upon soil, tillage, drainage, and irrigation as such, but upon the relation of soil, tillage, drainage, and irrigation to the environment of the plant, namely, to light, heat, moisture, air, plant food, and repressive agencies. The special province of the agronomist is to consider how soil, tillage, drainage, irrigation, and the various cultural methods of the farmer may modify the environment and thus increase the crop, and, so far as man may modify the environment, how it may be accomplished economically. No less important is the influence of heredity in the production of crops and the practical methods by which plants may be improved.

To what extent the teaching will be confined to a consideration of man's influence in making use of fundamental laws and how much time will be employed in stating fundamental laws must depend upon the thoroughness with which the student has studied botany, physiology, and chemistry.

In any case the application of these fundamental laws must be made. For example, if the students have had chemistry, the teacher must spend some time in considering the function and relation of the 14 elements chiefly concerned in the production of soil, air, plants, and animals. If, however, the students have not had any chemistry, it will be necessary in addition to spend some time in teaching the students the alphabet of chemistry. From the syllabus it will be seen that the plant may be studied from the standpoint of its composition, structure, physiology (activities), heredity, and environment. Since a plant is the result of two forces, its heredity power and its environment, general consideration is first given to the methods of plant improvement and to those cultural methods by which the plant's environment is modified. Following these general considerations each individual crop may be studied from the standpoint of its structure, its composition, its physiology or activities, its heredity or improvement, its environment or cultural methods, and, finally, its economical use and disposal. The number and kind of crops to be studied will vary with the time at the disposal of the teacher and, to some extent at least, with the character of the local agricultural industries. The syllabus outlines an illustration of the order and possible topics for discussion, leaving it to the teacher to select those that may be best employed. It is not expected that any high school will be able to teach all the topics here mentioned.

SYLLABUS.

1. The plant, how studied:
    1. Composition.
    2. Structure.
    3. Physiology.
    4. Heredity.
    5. Environment.
2. Composition:
    1. Essential elements.
    2. Function of elements.
    3. Water.
    4. Ash.
    5. Protein.
    6. Carbohydrates.
        1. Cellulose.
        2. Starch.
        3. Sugars.
    7. Fat.
3. Structure:
    1. Cells.
    2. Roots.
    3. Stems.
    4. Leaves.
    5. Inflorescence.
4. Physiology:
    1. The plant activities.
    2. The processes of growth.
    3. Irritability.
    4. The kinds of propagation.
    5. Propagation by seeds.
    6. Propagation by buds.
5. Heredity:
    1. Principles.
    2. Processes.

5. Heredity—Continued.
    3. Steps in improvement of plants.
        1. Variation.
            1. Environment.
            2. Crossing.
        . Selection.
        . Testing hereditary power.
    4. Illustrations of improvement in plants.
    5. Methods of improvement.
6. Environment:
    1. Light.
    2. Heat.
    3. Moisture.
    4. Air.
    5. Plant food.
    6. Repressive agencies.
7. Light and heat:
    1. Relative interdependence.
    2. Effect.
    3. Influence of character of light.
    4. Influence of seasons.
    5. Temperature for germination and growth.
    6. How modified.
        1. Color.
        2. Evaporation.
        3. Topography.
        4. Character of soil.
        5. Cultivation.
        6. Drainage.
        7. Rolling.
        8. Thickness of planting.
        9. Fermentation.
        10. Artificial means.
            1. Screens.
            2. Electricity.
            3. Artificial heat.
8. Moisture:
    1. Purpose.
    2. Importance.
    3. Quantity required.
    4. How modified.
        1. Kind of soil.
        2. Topography.
        3. Fertilizers and other amendments.
        4. Cultivation.
        5. Drainage and irrigation.
9. Air:
    1. Function above ground.
        1. Oxygen.
        2. Carbon dioxid.
    2. Function in soils.
        1. Oxygen
        2. Nitrogen.
        3. Removal of carbon dioxid.
    3. Processes of soil ventilation.
        1. By diffusion.
        2. By expansion and contraction of air due to temperature.
        3. By expansion and compression due to barometric pressure.
        4. Suctional effect of gusts of wind.
        5. Air absorbed by rain water.
        6. By removal of water, through drainage, evaporation, and transpiration of plants.
10. Plant food:
    1. Elements needed.
        1. Function.
        2. Sources.
            1. Air.
            2. Soil.
            3. Fertilizers.
11. Soil:
    1. Functions.
    2. Properties.
    3. Kinds.
    4. As a source of plant food.
        1. Importance compared with other sources.
        2. How modified.
            1. Kind of soil.
            2. Topography (erosion).
            3. Tillage.
            4. Drainage and irrigation.
            5. Fertilizers.
            6. Systems of cropping.
12. Kinds of soil.
13. Topography.

14. Tillage:
    1. Purpose and effects.
    2. Methods.
15. Drainage:
    1. Purpose and effects.
    2. Methods.
16. Irrigation:
    1. Purpose and effects.
    2. Methods.
17. Fertilizers:
    1. According to constituents.
        1. Nitrogenous.
        2. Phosphoric.
        3. Potassic.
        4. Other amendments.
    2. According to form.
        1. Farm manures.
            1. Green manures.
            2. Animal manures.
        2. Commercial fertilizers.
18. Farm manures:
    1. Properties.
    2. Sources.
    3. Uses.
    4. Preparation, care, and handling.
    5. Application.
    6. Economy.
19. Commercial fertilizers:
    1. Sources.
    2. Uses.
    3. Application.
    4. Economy.
20. Nitrogen:
    1. Source.
    2. Fixation of free nitrogen.
        1. With certain plants.
        2. Without plants.
        3. Organisms.
        4. Cause of tubercles.
        5. Effect of organisms.
        6. Influence of conditions.
20. Nitrogen—Continued.
    3. Nitrification.
    4. Denitrification.
    5. Loss through drainage.
21. Repressive agencies:
    1. Insect and other animals.
    2. Diseases.
    3. Weeds.
    4. Unfavorable weather.
    5. Acidity and alkalinity of soil.
    6. Toxic agencies.
22. Rotation of crops:
    1. Principles.
    2. Systems.
23. Classification of economic plants:
    1. Cereals.
    2. Grasses.
    3. Legumes.
    4. Vegetables.
    5. Fruits.
    6. Tubers.
    7. Roots.
    8. Sugar plants.
    9. Oil plants.
    10. Fiber plants.
    11. Stimulants.
    12. Medicinal and aromatic plants.
24. Cereals:
    1. Wheat.
    2. Indian corn (maize).
    3. Oats.
    4. Barley.
    5. Rye.
    6. Rice.
    7. Sorghum.
    8. Buckwheat.

    (Other groups of plants may be classified in like manner.)
25. As many individual crops may be treated as time will permit.

An outline of topics on wheat is submitted, which is believed to be much too complete for secondary instruction, but may be readily modified to suit the character of instruction required.

WHEAT.

A. Structure:
    1. Relationships; 2, roots; 3, culms; 4, leaves; 5, tillering; 6, organs of reproduction; 7, the true flower; 8, the spikelet; 9, the spike; 10, the grain; 11, the embryo; 12, the endosperm; 13, the aleurone layer; 14, the bran; 15, physical properties.

B. Composition:
1. Composition; 2, water; 3, ash; 4, protein; 5, gluten; 6, relation of weight per bushel to nitrogen content; 7, influence of environment on composition of grain; 8, germination.

C. Botanical relations:
1. Species of wheat; 2, Einkorn; 3, Spelt; 4, Emmer; 5, Common wheat; 6, Club, or square-head wheat; 7, Poulard wheat; 8, Durum wheat; 9, Polish wheat; 10, spring and winter wheats.

D. Classification of varieties:
1. The importance of variety; 2, the best variety; 3, variety names; 4, pedigree wheat; 5, number of varieties; 6, variety characteristics; 7, variety groups; 8, desirable qualities; 9, score card; 10, market classification; 11, soft winter varieties; 12, hard winter varieties; 13, hard spring varieties; 14, white varieties.

E. Improvement of varieties:
1. New varieties; 2, the introduction of foreign varieties; 3, improvement by selection; 4, varieties through crossing; 5, the possibility of cross-fertilization; 6, the law of cross-fertilization; 7, importance of crossing as a method of improvement; 8, method of finding and testing new strains or varieties.

F. Climate:
1. Conditions of successful wheat culture; 2, effect of climate upon geographical distribution; 3, effect of climate upon quality; 4, effect of climate upon growth; 5, accumulation of soil constituents at different stages of growth; 6, winterkilling.

G. The soil and its amendments:
1. The choice of soil; 2, effect of change of soil on yield; 3, the use of fertilizers; 4, indirect fertilization; 5, rotations; 6, carriers of fertilizing constituents; 7, relative importance of fertilizing constituents; 8, amount of fertilizers; 9, time and manner of applying commercial fertilizers; 10, farm manure; 11, mulching.

H. Cultural methods:
1. Time of plowing; 2, depth of plowing; 3, preparing seed bed without plowing; 4, time of sowing; 5, depth of sowing; 6, drilling compared with broadcasting; 7, quantity of seed per acre; 8, influence of size of seed; 9, treatment of seed; 10, wheat-seeding machinery; 11, cultivation; 12, rolling.

I. Weeds, fungus diseases, and insect enemies:
1. Weeds: (*a*) chess or cheat; (*b*) darnel; (*c*) cockle; (*d*) wild garlic; (*e*) wheat-thief; 2, fungus diseases: (*a*) rust; (*b*) wheat scab; (*c*) loose smut; (*d*) stinking smut; 3, insect enemies of growing wheat: (*a*) chinch bug; (*b*) Hessian fly; (*c*) wheat joint-worm; (*d*) wheat midge; (*e*) grain aphides; (*f*) army worm; (*g*) grasshoppers.

J. Harvesting and preservation:
1. Date of harvesting; 2, influence of maturity on yield; 3, influence of ripening upon composition; 4, influence of shocking; 5, method of shocking; 6, methods of harvesting; 7, self-rake reaper; 8, the self-binding harvester; 9, the header; 10, the combined harvester and thrasher; 11, thrashing; 12, storing; 13, elevators.

K. Uses and preparation for use:
1. Uses; 2, food for domestic animals; 3, source, amount, and quality of flour; 4, grades of flour; 5, graham and entire wheat flour; 6, amount

of bread from flour; 7, milling machinery; 8, purifier; 9, the by-products of wheat; 10, composition of by-products; 11, food value of by-products.

L. Production and marketing:

1. Wheat crop of the world; 2, wheat crop of the United States; 3, progress of wheat production; 4, center of wheat production; 5, winter wheat and spring wheat; 6, production of flour; 7, consumption of wheat per capita; 8, yield per acre; 9, cost of production; 10, export of wheat and flour; 11, imports of wheat; 12, commercial grades.

M. History:

1. Antiquity; 2, original habitat; 3, reasons for culture.

GENERAL INSTRUCTIONS TO TEACHERS.

Since this is a new subject for high school work it seems desirable to give detailed suggestions on a few subjects for study. These directions and questions are not intended to be mandatory, but are intended to help teachers who are giving this work for the first time. This work does not cover the entire syllabus. When the schools and teachers become better equipped the work may be extended. In preparing these lessons first attention has been given to the question as to whether bulletins and other material could readily be secured. Some topics of prime importance have been omitted because there are no bulletins that can be secured to supply the entire class for study, while topics of less importance have been included because good bulletins are available. The lessons are to aid in doing work under present conditions and are not intended to represent an ideal high school course.

The study of agriculture gives the same sort of educational development as is given by the study of botany, physiology, physics, chemistry, and other sciences. From the unlimited number of subjects for scientific study it selects those which concern the plants and animals that are used on the farm. Each school should select for study the subjects that are of greatest importance in the community.

Since agriculture is based on so many sciences it is desirable that it follow the study of the other sciences that are taught in the school, particularly botany and chemistry. If a school can not teach chemistry it will be possible to give about two-thirds of the lessons outlined. But it is extremely desirable that chemistry be taught preceding the agriculture. It should be taught by the laboratory method. No work in high school agriculture should be attempted unless the school teaches botany. Those who wish to teach agriculture before they teach botany should use Office of Experiment Stations Bulletin 186, Exercises in Elementary Agriculture—Plant Production. Many of the exercises in that bulletin can also be used in high school work.

The student should thoroughly understand plant cells from a microscopical study of them; the embryo and its growth; tests for starch and proteids; the process of osmosis and the function of roots; the structure of stomata and use that the plant makes of oxygen and carbon dioxid; the formation of starch, its transfer through the stem, and its deposit as stored food in seeds and tubers; the process of fertilization; the nature of a fungus disease, from a microscopical study of bread mold or other fungus.

All other science work that is taught will help in agriculture. The subjects under physiology that are of most value as a preparation for agriculture are: Respiration; the kinds of foods, their digestion and the part that each plays in keeping up the body; bacteria and sanitation. If physical geography or geology is taught, the subjects of most value in preparing for agriculture are: The air, the weather, and the formation of soils. If zoology is taught, the work on insects will be of most value in preparing for the following lessons.

The teacher who gives the elementary agriculture should have a good knowledge of elementary botany and chemistry, and it is very desirable that he have some knowledge of physics, zoology, and geology. It is also desirable that the teacher be a man who has had some farm experience or who has studied some agriculture.

REQUIRED FREE REFERENCES.

Write to each of the following addresses stating that you wish the publication mentioned for your high school library and in your class in agriculture. If the teacher finds that he desires any of these for his private library, he should write for additional copies. The set in the high school library should be kept complete for future classes. On receipt of these the loose bulletins should be bound, or they may be punched and tied together with strings, and manila paper may be used for covers. These should be put in some place where pupils will have free access to them.

(1) Secretary of Agriculture, Washington, D. C.:

Ask to have the school placed on the mailing list for the Monthly List of Publications, and to be sent the following:

1 set of Farmers' Bulletins suitable to the locality.

1 copy of the List of Publications for Free Distribution.

1 copy of the List of Bulletins for Sale.

1 copy of each of the reprints of the areas that have been surveyed by the Bureau of Soils in your State.

Also ask for as many copies of "Separates from the Yearbook," Nos. 83, 124, 159, 279, 310, and 329, as there are students

in the class. One copy of this circular and of Office of Experiment Stations Bulletin 186 for each student will be convenient for some of the exercises. Also look over the list of recitations where pupils are to study Farmers' Bulletins. Make a list of these bulletins that you expect to use, and send for as many copies as there are students in the class. Where directions are given to "study and recite" on bulletins or extracts, it is expected that the teacher give out a copy to each pupil at the time when the lesson is assigned.

(2) Write to your Congressman for such copies of the Yearbook of the Department of Agriculture as he may have for distribution, stating that they are for your high school library.

(3) Write to your State experiment station for copies of available bulletins and reports, and ask to be placed on the mailing list.

(4) Write to the State board of agriculture and other agricultural societies for publications that they have for distribution.

(5) Copies of farm papers and country-life magazines are desirable for the high school reading table.

BOOK REFERENCES.

No references other than the above are absolutely necessary, but it is very desirable to have on the reference table one copy of as many of the following books as possible. At least half of these ought to be secured. If a cyclopedia of agriculture can be afforded it will be of much value. Several copies of each of the first four books will be desirable if the class numbers over half a dozen; also of the fifth book in regions where fertilizers are much used.

1. Physics of Agriculture, King.
2. Chemistry of Plant and Animal Life, Snyder.
3. Forage and Fiber Crops in America, Hunt.
4. Cereals in America, Hunt.
5. Fertilizers, Voorhees.
6. Experiments with Plants, Osterhout.
7. The Principles of Fruit Growing, Bailey.
8. The Fertility of the Land, Roberts.
9. The Farmstead, Roberts.
10. The Horticulturist's Rule Book, Bailey.
11. Corn Plants, Sargent.
12. The Practical Garden Book, Bailey.
13. The Soil, King.
14. Irrigation and Drainage, King.

The following are more elementary books:

15. Soils and How to Treat Them, Brooks.
16. Manures, Fertilizers, and Farm Crops, Brooks.
17. Principles of Agriculture, Bailey.
18. Agriculture for Beginners, Burkett, Stevens, and Hill.

19. First Principles of Agriculture, Goff and Mayne.
20. Elementary Agriculture, Bessey and others.
21. Agriculture through the Laboratory and School Garden, Jackson and Daugherty.
22. First Book of Farming, Goodrich.

EQUIPMENT.

It is desirable that the high school be equipped for regular laboratory work in botany, chemistry, and physics. If not so equipped, the following equipment is suggested for a class of ten in agriculture:

2 compound microscopes magnifying to 500 diameters, cost about $18.
2 balances for weighing to centigrams.
Spring balance.
1 dozen pint fruit jars.
1 dozen quart fruit jars.
4 dozen test tubes.
½ dozen beakers (drinking glasses may be substituted).
1 dozen 4-inch size flowerpots with saucers; 1 dozen 6-inch size flowerpots with saucers (tin cans and boxes may be substituted).
1 gasoline burner (a stove or laboratory burners are as good).
6 porcelain crucibles (iron spoons may be substituted).
2 thermometers.
Small magnifying glasses, magnifying 10 diameters.
1 "School set of economic seeds." These may be obtained at a nominal expense by writing to the Seed Laboratory, United States Department of Agriculture, Washington, D. C.

Other equipment required can be brought from home by students when it is needed.

It is essential that there be at least two windows at which plants may be kept growing for experimental purposes.

Whenever possible, it is desirable that several acres of land be available for school use. Those who are laying out new school grounds will do well to keep this in mind.

COLLECTION OF MATERIAL.

About 1 bushel each of sand, such as is used in plastering, sandy loam soil, and clay should be collected. Similarly collect about 3 quarts of leaf mold (well-rotted leaves). Also collect about 4 quarts of soil and subsoil from the same spot. All these should be put in the basement, where they will become air-dry for future class use. It is also desirable to have several bushels of good rich soil for use in growing house plants. Unless it is very rich, about one-fourth stable manure should be mixed with it.

Collect samples of the common diseases and insects for class study. Any of the following diseases or others that occur in the neigh-

borhood: Potato scab, apple scab, wheat rust, oat smut, brown rot of peaches and plums, black knot, apple canker, corn smut.

Fill two 1-quart jars with pure rain water for use in No. 22, unless you can distill water.

The following samples of fertilizers for exercise may be secured from a local dealer, or students may be able to bring them in, or they may be secured from the manufacturers. Secure the guaranty analysis and price of each sample. Get about 1 pint each of nitrate of soda or other form of nitrogen, muriate of potash or other form of potash, acid phosphate or other form of phosphoric acid, and at least two samples of complete fertilizers.

NOTEBOOKS.

Each student should keep a notebook, in which all field trips, demonstrations, and laboratory work should be written up, giving date, subject of the exercise, materials used, full description of how the work was done, drawings, all data secured, solution of problems, answers to questions that follow the demonstration and laboratory work or to similar questions prepared by the teacher. This should all be given in complete form in good English, not in detached sentences. This really amounts to a discussion or essay on the subject in which drawings, problems, and answers to questions are included.

Many of the demonstrations are of such a nature that they may be assigned to some student in the class, who will take entire charge of the preparation and management of the experiment. This may not very greatly reduce the work for the teacher, but it will be of much value to the students. The notebook discussion of demonstrations should state who did the work.

TIME REQUIRED.

The work here outlined is expected to be sufficient for one year. It can readily be adapted to half this amount of time by omitting exercises. It is desirable that there be three recitations a week and two double periods for laboratory work, field work, and demonstrations. When a field lesson is given, it is desirable that it be the last work of the day, so that it need not be finished at any scheduled time. The demonstration work may often be given in recitation periods. The figure in parentheses following the number of the exercise indicates the relative time that it is thought desirable to devote to the subject. More than this number of periods can be given to each topic and still complete the work in a year. This will give an opportunity to devote more time to those lessons that are of particular interest in the community. By securing the bulletins from the State experiment station, a study may be made of the agriculture of the State.

OUTLINE OF LECTURES, RECITATIONS, DEMONSTRATION, AND LABORATORY WORK FOR SECONDARY INSTRUCTION IN AGRONOMY.

1 (2) RECITATION. What is agriculture? Agronomy?

The teacher may give a talk on this subject, showing how agriculture rests on many sciences and the things with which agriculture deals. (See syllabus.) Then, taking up agronomy, call attention to the ways in which plants may be studied: 1, composition; 2, structure; 3, physiology; 4, heredity; and 5, environment.

High school botany, as taught at present, deals chiefly with structure and physiology. We will now take up the study of plants in all five ways, but will give most attention to environment and heredity. Little can be given on composition without a knowledge of chemistry.

When studying about light, heat, air, moisture, soils, tillage, drainage, etc., always keep in mind that these are not being studied as independent subjects, but are studied because they are important factors in the plant's environment.

2 (2) FIELD LESSON. Variation in plants.

Materials.—A field of corn; tape measure.

If there is danger that there will be no corn convenient, the teacher can get some one to leave a dozen hills or more uncut for this study, or a similar study may be given on another crop. The lesson may be given at any time during the fall. Each pupil to bring a tape measure from home. It is best to have the measurements made on different rows to secure independent work. Each pupil to work on 10 hills, or 10 stalks, if drilled or listed.

Number of hills, ———.
Number of stalks per hill, ———.
Number of suckers, ———.
Number of ears, ———.
Number of hills missing, ———.
Total stalks, ———.
Number of barren stalks, ———.
Average number of ears per stalk, ———.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Height of 10 stalks										
Height of ear										
Length of shank of ear										
Length of ear										
Direction of ear										
Number of leaves										

Suckers are side branches that come out from a stalk usually near the ground. The shank is the stem that holds the ear. Direction of the ear is horizontal or pointed upward or downward. A long, slender shank usually allows the ear to point downward. If it points upward, water is more likely to go into the ear and cause it to rot if left standing in the field. The husks may be pulled back to meas-

ure the ear. Notice the very great variation in each character. Why is this so? There must be a difference in the strength of different plants—an individuality. From which would we select seed? Find a stalk and ear that you think would be a good one to save for seed. It should not be good merely because it had more room to grow, but be good under the usual conditions. What uncertainty about its being good? Notice that pollen may have come from a poor stalk.

3 (2) Recitation. Selection of seed corn.

Study and recite on the above and on Farmers' Bulletin No. 229.

4 (1) Field Lesson. Variation in potatoes.

Materials.—Spring balance, pail, spading fork, or potato hook.

Dig 20 or more hills of potatoes. Weigh and count the large (marketable size) and small potatoes.

Hill.	Large.		Small.	
	Number.	Weight.	Number.	Weight.
1				
2				
Etc.				

Notice the variation in individual hills. Which hill would be the most desirable for seed? If all the large potatoes were used for seed, would you have only the good plants represented? Some boy will probably volunteer to do this work and report his results to the class.

5 (3) Recitation. Plant breeding.

Read and recite on Separate No. 83, Yearbook 1896 (Influence of Environment on the Origination of Plant Varieties); also have the pupils look over and read parts of Separates Nos. 124, Yearbook 1897 (Hybrids and their Utilization in Plant Breeding), and 159, Yearbook 1898 (Improvement in Plants by Selection).

The following points need to be brought out: The great variation in plants; any change in environment increases the variation; possibilities of improving cultivated varieties by selection; how hybrids are made; great variations thus caused; these variations may be desirable or otherwise; they furnish opportunity for selection; in selecting seed the entire plant should be considered, not a single potato, but the best hill; if selected from a pile, a good looking potato might have been the only good one in the hill. What would be a good way to select tomato seed? Corn seed? (Cereals in America, pages 14–26.)

6 (2) Field Study. Effect of light on plant growth.

In a truck garden notice the blanching of celery and the whiteness of shaded leaves of cabbage; notice the shaded parts of thickly sown

crops—how they lack the bright green colors. Call the attention of the pupils to the way in which plants growing in a poorly lighted room stretch toward the nearest window. Recall how potatoes sprouting in the cellar send their sprouts sometimes for a yard or more in the direction of the light. Notice the struggle of forest trees to send their branches up to the light. There will be exceptions, of course—some trees and shrubs which seem to do well under the cover of other trees, but in the main those trees which are shut off from the direct rays of the sun do not thrive. It will be an instructive object lesson to visit a forest and notice how on the edge of the woods the large limbs on all of the trees are on the side next to the open field. Why do trees growing in the thick forest become so much taller and more spindling than trees of the same variety growing in the open field? Does this habit of trees have any important economic bearing? Are trees with long, straight, clean trunks more or less valuable for timber than trees with low, bushy tops? What relation has this to the pruning of fruit trees?

7 (2) Demonstrations. Effect of excluding light from plants.

Construct of lath a screen 3 feet square. Place the laths 1 inch apart. At each corner attach a sharpened stake about 1 foot in length, to be driven into the ground. Place the screen over a portion of a lawn or a field of young wheat or oats. Observe the effect of shade (lack of light). In a week or two a marked contrast will be noticed between the shaded and unshaded portions. The same effect may be had by using a screen made by covering a framework of wood strips with brush.

The effect of cutting off light may be measured. Start wheat seedlings in two small pots or cans. When the seedlings are about an inch high mark each seedling with ink one-fourth inch from the tip. Give both pots plenty of moisture and warmth, but keep one covered with a cone of opaque paper or a pasteboard box. After two days measure the growth of the seedlings in each pot.

8 (2) Laboratory. Effect of heat on plant growth.

Prepare two seed testers with wheat. Subject one to heated and the other to freezing conditions—near a heated stove for the first and in a refrigerator for the second. If all conditions are correct the plants subjected to the high temperature will germinate while those subjected to the low will not. What farm plants germinate first in the spring? What ones fail to start until the soil is warmer? What relation to the amount of cold that the seedlings will stand?

In the spring or fall when the weather is cool, but not frosty, radish seeds may be started indoors in two boxes about a foot square and 8 or 10 inches deep, with 3 inches of good soil in the bottom. As

soon as the young plants are well started remove all but 5 or 6 of the strongest plants in each box, then set the boxes side by side out of doors. Cover one box with a pane of glass, leaving a small crack for ventilation, but aside from this treat them exactly alike. Water when necessary. Put a thermometer in each box in such a position that temperatures can be read without disturbing the boxes. Take and record temperatures several times daily for a week and observe differences in the development of the plants. Draw conclusions concerning the relation of heat to the growth of plants. Explain the difference in temperature in the two boxes.

9 (1) Recitation. Effect of moisture.

The teacher should give a talk on the effect of moisture on plant growth as outlined in the syllabus by calling attention to the purpose and importance of moisture, the quantity required, and how different types of soil, topography, etc., modify the amount of moisture available to plants. Study and recite on Farmers' Bulletin 245, pages 6, 7, and Farmers' Bulletin 257, pages 7–9.

10 (2) Laboratory. Effect of moisture.

Fill three small pots or cans with oven-dried garden soil. Plant a few grains of wheat or other quick-sprouting grain in each pot. Apply no moisture to one of the pots, a moderate amount to another pot, and keep the third pot saturated with water. Subject the three pots to the same conditions of heat and light. As soon as the grain appears above the ground in any of the pots, have the pupils make careful observations on its growth under different conditions of moisture, and continue these observations for two or three weeks. Which is better for the growth of plants, a moderately wet soil or a saturated soil? What can be said for or against putting in grain when the soil is water-logged? What bearing has this exercise on the importance of draining wet soils?

11 (1) Recitation. Effect of air.

The teacher should give a talk on the use of air to plants—the functions of oxygen and carbon dioxid above ground, and the functions of oxygen and nitrogen below the ground. Have pupils study and recite on Farmers' Bulletin 245, page 7, and Farmers' Bulletin 257, page 6. See also Experiments with Plants, pages 187–201 and pages 278–285.

12 (2) Laboratory. Effect of air.

Perform Exercise 26 in Office of Experiment Stations Bulletin 186.

13 (3) Field Lesson. Origin of soils.

This subject may be taught in physical geography. If the following points have not been taught, one or more field trips should be devoted to them; in order to give a successful field lesson the teacher should go over the ground some time before taking the class out. Geological origin of the soils of the region. Evidences of this origin seen in the field trip. Find a rounded pebble; what rounded it? Find a "rotten" stone or a place where a rock is covered by disintegrating rock; explain. Is the farm land rolling? Account for the low places. What part has the wind played in soil formation? Find some evidence of the work of earthworms, woodchucks, prairie dogs, or other animals in soil formation. Find evidence of the part played by plants in soil formation—decay of roots, leaves, etc. Cross a meadow or pasture. Are there any spots that are covered with weeds? Are the weeds there chiefly because they killed the grass or because the grass failed to grow? Notice that nature rarely leaves any permanently bare ground. Of what value are weeds in soil formation? If there are steep hills in the region, notice the relative erosion on hillsides that are forested, tilled, pastured. What use is made of steep hillsides in the neighborhood? Do better crops grow on a sidehill or at the foot of the hill? Why? Why are valleys generally fertile? Nearly all these points may be answered in crossing any farm. (Experiments with Plants, pages 109–111; Physics of Agriculture, pages 49–68; The Soil, pages 1–70.)

14 (1) Recitation on No. 13.

15 (3) Field Study. Soil and subsoil, humus, organic matter, types of soil.

Materials.—Rule, spade, 6 fruit jars.

Go to a near-by farm. Dig a hole about 2 feet deep in a clay soil. What is the color of the soil? Of the subsoil? Which is more compact? How deep is the soil?

Find pieces of partly decayed roots and stems. What color are they? Which contains more of this organic matter or humus, the soil or subsoil? How does a farmer increase the amount of humus in the soil?

Have each pupil rub samples of soil and subsoil between his fingers so as to become familiar with its texture. Fill one of the jars with soil and one with subsoil and cover each. Label the first can clay soil, the second clay subsoil; also date each. The samples are to be kept tightly covered for use in No. 26. Similarly study and collect a sand or sandy loam. Also collect similar samples from a fertile soil that is producing extra good crops. Teach the terms "sand," "sandy loam," "loam," "silt loam," "clay loam," and "clay." Find samples

of as many of these as possible. Which are sticky? Which is made of the largest particles?

There are usually 6 to 12 inches of darker-colored surface "soil," below which is the "subsoil." In arid regions the difference is not marked. Plants and animals are organic matter (organisms); as these decay in the soil they form "humus." The decaying plants usually turn black, like charcoal. We would expect this, since charcoal is the result of partial burning and humus the result of partial oxidation. What is oxidation? There is naturally more of this organic matter in the soil than in the subsoil, hence the darker color. On lowlands and in marshes the water partly excludes the air, so that the organic matter accumulates and gives them the darker color. Moist soil is also darker than dry soil. The fine, sticky soils are clay soils. Bricks are usually made of clay. The sand that is used for plaster and mortar is the other extreme. A loam soil is one that is composed of about half sand and half finer particles. A clay loam and a sandy loam are intermediate grades. In some regions it will be difficult to find sand, loam, and clay, but ordinarily a very short trip will show all kinds. (Experiments with Plants, pages 103–109; The Soil, pages 99–101; Physics of Agriculture, pages 49–68.)

16 (1) Recitation on No. 15.

17 (3) Field Lesson. Relation of crops to types of soils, plant roots, nodules on legumes.

Materials.—Rule, spade.

(*a*) Go across several farms. Notice what kinds of crops are being grown on sandy soils, on clay soils, on wet land. Some crops can be raised on a great variety of soils. Thus, timothy hay can be grown successfully on clays, clay loams, and loams, or even on fine sand, but it usually does best on the clay or clay loams. Peaches usually thrive best on fine, sandy soils. White or Irish potatoes require a loose, moist soil for their best development. To what extent are the crops varied with the kinds of soil in your region?

(*b*) Dig down beside a cornstalk; notice how deep it is to the first roots; to the deepest roots. Repeat in several places and on different kinds of soil if possible. How deep could a cultivator go without hurting the roots? Similarly, find the depth and lateral extent of roots of clover and other crops. As the roots decay they add to the humus and make the soil more productive. What plant roots examined would tend to deepen the soil and be most valuable as they decay?

(*c*) Carefully dig up a clover plant; look for nodules on the roots. Bacteria live in these nodules. By means of these nitrogen is taken from the air in the soil and is made available for plant use. Nitrogen

is one of the most important foods for plants. It is the most expensive part of common fertilizers. Only members of the pea family (legumes) are capable of thus getting nitrogen. Why does clover benefit a crop that follows it? Consider the depth and amount of roots as well as the nodules. Dig any of the following or other legumes that you see and look for nodules: White clover, sweet clover, beans, peas, vetches, alfalfa, etc. Later lessons will consider this topic again. (Farmers' Bulletin 215, page 15; Experiments with Plants, pages 133–135 and 149; Physics of Agriculture, pages 150–157.)

18 (1) Recitation on No. 17.

19 (1) Recitation. Root systems of plants.

Study and recite on Farmers' Bulletin 233, pages 5–11.

20 (1) Demonstration. Relative productivity of soil and subsoil. (For humid regions.)

Materials.—Two 6-inch pots; wheat seed; soil and subsoil from the same place. See page 10.

Fill one pot with the surface soil and the other with subsoil and plant about a dozen kernels of wheat an inch deep in each pot. Keep these watered and see which makes the better growth. Why? What effect would the rapid washing away of surface soil have on the fertility of a side hill? How can the soil be kept from washing? Could subsoil become a good soil? Deep plowing deepens the surface soil and sometimes makes it more fertile. If one wishes to deepen a soil that has always been plowed shallow, it is usually better to plow a little deeper each year rather than to plow too deep the first time. Why? What is a "dead furrow" and why so named? (Physics of Agriculture, page 49.)

21 (2) Demonstration or Laboratory. Soil particles and their separation.

Materials.—Two breakers, 3 fruit jars, pan. Prepare for (*b*) a day in advance.

(*a*) Put about a tablespoonful of sand in one beaker and clay in another. Shake each one and allow to settle. Which settles more rapidly? Why? Which would be deposited first when a swift stream is checked? Where in your neighborhood is there evidence of this sorting power of water? Did the glaciers thus sort soil? How could we separate the different-sized particles in a soil?

(*b*) The day before this lesson is given put about four tablespoonfuls of a loam soil in a fruit jar and nearly fill with water. Cover. Shake occasionally. After standing a day, shake thoroughly. Allow to settle one minute. Pour the roily water into another jar; allow this to stand one hour. Pour off the roily water and evaporate by

setting on a stove or over a flame. When dry (which will probably be for the next lesson), examine the dry separates. The part that settled out first is sand, the second is silt, and the finest material is clay. Have the pupils examine them to find differences in texture. Which ones stick together? Would pure clay or pure sand make a good soil? Why? Save the materials for No. 23. (Experiments with Plants, pages 103–105.)

22 (1) Recitation on No. 21.

23 (2) Laboratory. Microscopical examination of soil particles.

Materials.—Compound microscope.

Examine the sand particles (×50), i. e., use the combination of eyepieces and objectives that magnifies 50 diameters. Mix the silt with a little water and examine a drop (×100). Only a little of the silt is better than too much in a drop. Mix the clay with water and examine a drop of the slightly roily water (×500). Have each pupil make a drawing of a few particles of each. Notice that the soil particles are really minute rocks and humus. Find black particles of humus and draw. Find flocculated particles of clay, i. e., a number of particles united to form a compound particle. If such particles are not readily seen, a little clay soil moistened and a drop put under the microscope will show them. Do you see any reason for having the soil soak a day? Keeping a clay soil in good condition is largely a matter of keeping the particles thus flocculated or united into small crumbs. (Experiments with Plants, pages 124–129; Farmers' Bulletin 187, pages 6, 7.)

24 (2) Demonstration. One effect of humus and of lime on a clay soil. (For humid regions.)

Materials.—Clay, $\frac{1}{4}$ pound unslacked lime, leaf mold (page 10), wide mouth bottles.

(*a*) An hour or more before the class period the lime should be nearly covered with water to slake it. Divide the clay into three equal parts. To the first part add water; to the second add water and about half its volume of humus; to the third part add lime milk. Make each into a ball and set aside to dry. In a few days examine and see which is more mellow. What do you conclude as to the probable effect of working clay land when too wet? What is one value of organic matter in a clay soil? What is one value of using lime on a clay soil? In what way do farmers add organic matter to their soils?

(*b*) Put about a tablespoonful of clay in each of the two bottles. Fill with water and shake. Add a little lime milk to one bottle. Which one settles more rapidly? Why? Is lime used on soils in your vicinity? (Experiments with Plants, pages 129 and 152.)

25 (1) RECITATION. Humus in soils and its value.

Study and recite on Farmers' Bulletins 78, pages 5–9, and 144, pages 5, 6.

26 (4) LABORATORY. Determination of the per cent of water, organic matter, and mineral matter in soils.

Materials.—Soil samples collected under No. 15, porcelain crucibles, balances.

Give each pupil one of the six soil samples. If there are more than six in the class, results may be secured on all the samples. Weigh the crucible. Put 10 grams of the sample in it. Weigh before the water has time to evaporate much. Heat this a little hotter than boiling water, but do not burn it; one hour at 110° C. is about right. Weigh again. This gives the amount of water evaporated. Now heat very hot. After it is thoroughly burned for about one hour, weigh. Compute and tabulate results as follows:

	Sandy loam.		Clay.		Fertile soil.	
	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.
Weight of crucible----grams						
Weight of crucible and soil----do						
Weight of soil----do	10	10	10	10	10	10
Weight of both when dry----do						
Per cent of water						
Weight of both after burning---grams						
Weight of organic matter						
Per cent of organic matter						
Per cent of mineral matter						

What change in color took place as the soil dried? Is the color of the soil changed by rain? What change in color after the soil was burned? After burning only mineral matter remains. Compare this burning with burning wood. Which kind of soil contained more water? More organic matter? Do the surface soils or the subsoils contain more organic matter?

Each pupil may record the results on each sample, as stated above, stating who did the work for each one. If the school does not have crucibles and laboratory burners the soil may be dried over a stove and be burned in an iron spoon in the stove.

For classes that have had chemistry. The red and yellow colors of soil are usually due to iron. Ferric compounds cause the red colors; ferrous compounds cause the yellow colors. Why do some red soils have a yellow subsoil? Explain the formation of red brick from yellow clay.

27 (1) RECITATION on No. 26.

28 (1) DEMONSTRATION. Per cent of air in soils.

Materials.—Six beakers, graduate, six soil samples collected in No. 15.

Put a measured amount of soil (about 250 cc.) into each beaker. Pour water from the graduate (containing a measured quantity of water) until it just rises to the surface of the soil. How much water does it take in each case? Record the results as follows:

	Sandy soil.		Clay.		Fertile soil.	
	Soil.	Subsoil.	Soil.	Subsoil.	Soil.	Subsoil.
Volume of soil						
Volume of water added						
Per cent of air space						

The amount of water required is an approximate measure of the air space. If the soil were dry, the air space would, of course, be greater. This determines the space for the soil as collected in the field. Which soil contains more air? (Experiments with Plants, page 130; Farmers' Bulletin 187, page 7; Physics of Agriculture, pages 204–211.)

29 (1) Demonstration. Soil solutions.

Materials.—Four or more "slips" of Wandering Jew or Inch Plant (Tradescantia), two bottles, two crucibles, well water, rain water, or distilled water.

(*a*) Evaporate some well water in one crucible and some rain water in another. What is left in each case? What causes the inside of a teakettle to become coated?

(*b*) Put two of the slips in each bottle, fill one with well water and one with rain water. Change the water about three times a week, until the results are secured. In which do the plants grow best? Why? Water is necessary for plant growth, but pure water is not enough. The soil water dissolves the mineral matter that is also necessary. Crops get their food from the soil by absorbing this soil solution. (Experiments with Plants, page 138; Physics of Agriculture, pages 92–95.)

30 (1) Recitation. Physical composition of soil.

1. Solid matter.
   (*a*) Mineral matter, No. 26.
   (*b*) Organic matter, No. 26.
2. Liquid matter, soil water or soil solution, Nos. 26 and 29.
3. Gaseous matter.
   (*a*) Air, No. 28.
   (*b*) Carbon dioxid (carbonic-acid gas).
   (*c*) Water vapor.

Tell what you can of the value of each of these in crop production.

31 (1) DEMONSTRATION. Water capacity of soils. Solution of plant food.

Materials.—Air-dry sand, clay, loam, leaf mold, spring balance, four tin cans or paint cans with holes punched in bottom, holes in side, and string tied across for a bail.

(*a*) Weigh each can. Fill two-thirds full, one with each of the three soils, one with mixed clay and leaf mold, one with mixed sand and leaf mold. Add water till thoroughly wet. Let this drain off for about fifteen minutes. Weigh.

	Sand.	Sand and leaf mold.	Loam.	Clay.	Clay and leaf mold.
Weight of can					
Weight of can and soil					
Weight of soil					
Weight of both, with water					
Weight of water					
Per cent of water					

The soil should be very dry before this experiment. It will still contain some water, so that the results will all be too low. If the soil and leaf mold are all baked in an oven before the experiment the results should be accurate. Or small amounts of the saturated soil may be weighed out in crucibles and evaporated as in No. 26.

Dip a pebble in water. Notice the water that remains when it is removed. Where is the water held? Suppose that the pebble were broken in two, what effect would this have on its water-holding capacity? Why does sand hold less water than clay? What effect on water capacity does the addition of organic matter have? Notice that the organic matter not only holds water on its surface, but all through it, like a piece of bread that soaks up water. Give two ways in which a farmer might increase the water-holding capacity of his soils.

(*b*) Plants obtain their food by absorbing the soil solution (see No. 29. Since the film of water that surrounds the soil particles dissolves this food, what effect would pulverizing the soil have on the amount dissolved? It has been said that "tillage is manure." Do you see one reason for this statement? How do plants get their food from the soil? (Should be taught in botany.) (Physics of Agriculture, pages 131, 132 and 145–150.)

32 (1) LABORATORY OR DEMONSTRATION. "Warm" and "cold" soils.

Materials.—Two thermometers, two flowerpots, one beaker, sand, clay.

Tie a piece of cloth around the bulb of one thermometer. Hang this above the beaker so that the cloth is in the water and the bulb a

little above it. (The water should be about as warm as the room.) Leave the other thermometer in the air outside the beaker. In about fifteen minutes read both thermometers and take the temperature of the water.

Temperature of air, ———.
Temperature of wet bulb, ———.
Temperature of water, ———.

Why is the wet-bulb thermometer colder than either the air or water? Why do the hands feel cold when wet? Of what value is perspiration? Call attention to the heat needed to evaporate a kettle of water. In No. 21 it was found that clay held more water than sand. When the ground thaws out in the spring and evaporation becomes more rapid, which would be the warmer soil? Why? We commonly speak of sandy soils as "warm" soils and clay as a "cold" soil. Which is best adapted to growing early garden or truck crops? Early spring plowing loosens the soil so that the water evaporates. After this has evaporated the plowed soil becomes the warmer. Why? (Physics of Agriculture, page 220.)

33 (1) Recitation on Nos. 31 and 32.

34 (1) Demonstration. Relation of color to temperature.

Materials.—Two thermometers, soil, white-chalk dust, soot, two small boxes—crayon boxes will do.

Fill each box nearly full of soil. Bury the bulb of a thermometer about an inch deep in each. Cover one with chalk dust and the other with soot. Read the thermometers from time to time. Which is warmer? Why? Which color of clothing is warmer in summer? Black objects absorb a large part of the heat rays, while white objects reflect them. In spite of this, a light-colored sand may be warmer than a dark-colored clay. Why? See No. 32. (Physics of Agriculture, page 217.)

35 (3) Field Lesson. Soil temperatures.

Materials.—Two or more thermometers.

It is best to take this trip on a bright day in the spring about the time that spring plowing begins. To take the temperature of a soil, bury the bulb of the thermometer about 3 inches deep in the soil. Very great care must be exercised not to break the thermometer. Leave ten to twenty minutes, so as to get the correct temperature. Take the temperature on a north and on a south slope, also of clay and sand, of unplowed and freshly plowed fields, of grass land and tilled fields. In each case try to find adjacent soils that are alike except in the two things to be compared. You will probably find that the one mentioned second in each case is the warmer. Why? (Physics of Agriculture, pages 212–222.)

36 (1) Recitation on No. 35.

37 (2) Demonstration. Capillary rise of water in soils.

Materials.—Two small glass plates, three glass tubes 3 feet long and 1½ to 2 inches in diameter, pan of water, rubber bands, cloth and sand, loam and clay. Three lamp chimneys may be used in place of the glass tubes.

(*a*) Fasten the two pieces of glass together by a rubber band. Put a little splint at one side and set on edge in water. Notice that the water rises between the plates and that it rises highest on the side where the plates are nearest together. Draw this.

(*b*) Put a piece of cloth over the end of each tube and fasten with a rubber band. Fill each with one of the soils. Set in the pan of water. In which does the water rise most rapidly? Record the results as follows:

Time.	Height of water.		
	Sand.	Loam.	Clay.
One-half hour			
1 hour			
1 day			
2 days			

Continue for about a week. In which does the water rise highest? Why? Notice that it rose highest between the plates where they were nearest together and rises highest in the soil that has the finest spaces. Compare with the rise of oil in a lampwick, ink in a blotter, etc. What is the object of compacting the soil over seeds when planted? In what different ways is this done? (Farmers' Bulletin 218, page 13; Physics of Agriculture, pages 161–174; Experiments with Plants, pages 116, 117.)

38 (2) Demonstration. Evaporation from the soil (special importance in arid regions).

Materials.—Spring balance; three tin cans, holes punched in side and string for a bale, the same as used in No. 31; soil; fine grass.

Fill each can nearly full of the soil. Water each with the same amount of water. Cover the top of one with grass. Weigh. As soon as the surface is dry enough, stir the surface on one about an inch deep. Keep this stirred. Weigh every school day for about two weeks.

Date.	Bare surface.		Cultivated.		Grass mulch.	
	Weight.	Loss.	Weight.	Loss.	Weight.	Loss.

Which loses weight most rapidly? Why? What is one use of cultivation during a dry time? Notice that if we stir the soil when it is moist we hasten the evaporation in the part stirred. In dry weather this loose soil may act as a dust mulch to prevent evaporation. Tillage may, therefore, first hasten and then lessen evaporation. What would its general effect be in a wet season? In a dry season? Why is the soil under a board moist? (Experiments with Plants, page 115.)

39 (1) Demonstration. Drainage.

Materials.—Two flowerpots with soil; two geraniums or other plants growing in pots.

Set one geranium in a dish of water. Plant corn in two other pots, and stand one in a dish of water. Keep water constantly in the dishes under the two pots and water the other two in the usual way. Notice the effect of the excess of water on the geranium and on the germination and growth of the corn. If the corn in the wet pot grows, empty both pots and examine the roots. In which do the roots go deeper? What is the effect of flooding on field crops? On trees? Some crops will live on soils that are so wet that other crops would be killed. What ones? What kind of material underlies the soil in your neighborhood at depths of 3 to 10 feet—sand, gravel, clay, rock? This can be answered by observing cuts in the roads. Is the soil naturally well drained? (Physics of Agriculture, pages 204, 205.)

40 (1) Recitation and Demonstration. Weight of soils.

Materials.—Spring balance, sand, clay.

Fill a can with sand and weigh. Fill equally full of clay and weigh. Which is heavier? We commonly speak of clay soils as "heavy" and sandy soils as "light." This does not refer to actual weight, but refers to the ease of stirring them when tilling the soil. Which is easier to stir? Also recite on No. 39.

41 (3) Recitation. Drainage of farm lands.

Study and recite on Farmers' Bulletin 187. Give these lessons if drainage is much needed in the vicinity.

42 (2) Recitation. Worn-out soils.

Study and recite on Farmers' Bulletin 245.

43 (2) Recitation. Functions of roots and leaves; respiration, formation and translocation of plant food.

Study of root hairs and their function and of osmosis should be made in botany; also a study of respiration, transpiration, formation and translocation of plant food, microscopic study of surface of epidermis. All this work should be thoroughly understood.

The following demonstrations may be given in botany. If they have not been so given they may be given in agriculture. Also study and demonstrate osmosis.

(*a*) Microscopical drawing of a section of a seed, showing starch grains and proteid material. Where is the starch formed? Under what conditions is it formed? How does it get to the kernel of corn? What is the test for it? Have sprouted kernels of corn to be tasted in comparison with dry ones? Account for the sweet taste of the sprouting kernels.

(*b*) In studying transpiration, if a plant is growing in a can the surface of the soil may be covered with a thin layer of paraffin. The plant and can may then be weighed from day to day to determine the transpiration on different days. Water may be added through a funnel that pierces the paraffin.

(*c*) Break off two leaves of a geranium or other plant. Put the petiole of one in water and leave the blade in the air; put half the blade of the other in water and leave the petiole and remainder of the leaf in the air. Which wilts first? Does a plant take up dew or rain through its leaves? A tree builds a large trunk in the air, but instead of making a hole in the ground it lifts the soil. Where then did the material come from?

(*d*) Cut branches of apple and other trees about 3 feet long and keep in water. Renew the water twice a week. The blossoms and leaves will probably open. Where does the food for this growth come from? Do you see any reason why an orchard should be well cared for in a year when there is no crop?

(*e*) Notice that it is the stored food that makes the ordinary plants of value to us. The first part of the life of many plants is spent in the storage of food and the second part in the transfer of this food to the seed. Account for the hollow radish or turnip that has grown seed. Why is hay better if cut before seed is formed? Which would make better feed, the straw part of the oats cut green or cut when ripe?

(*f*) Collect nasturtium leaves or other leaves in the afternoon and in the morning before daylight. Boil them in water as soon as removed and soak in alcohol to remove the chlorophyll. These will keep till needed for class use. Test each for starch. Explain the smaller amount of starch in the ones collected in the morning. A similar test may be made of the leaves of a tree collected in the spring and in the fall just as they are dropping. Material of this kind may be collected and preserved for future classes. Omit this exercise if found too difficult. Teacher or pupil read Physics of Agriculture, pages 142–147.

44 (2) Demonstration. Plant foods.

Materials.—Seven 4-inch pots, balances, sand.

Fill each pot with sand such as is used in plastering, or other pure sand. Number the pots. Add plant foods as follows:

1. Nothing.
2. 10 grams lime.
3. 10 grams lime, 1 gram potassium chlorid or sulphate.
4. 10 grams lime, 1 gram superphosphate or phosphoric acid.
5. 10 grams lime, 1 gram sodium nitrate.
6. 10 grams lime, 1 gram each of the compounds used in Nos. 3, 4, 5.
7. About a half pint of stable manure.

Mix the material in each pot, then plant about 5 kernels of wheat in each. Record the growth of the plants from day to day, noting differences in color and amount of growth. These should be grown until the differences are apparent. Apply several ounces of sodium nitrate to a plant in a small pot. The plant will probably be killed by the too strong food. (Experiments with Plants, pp. 139–160.)

45 (1) Recitation. (Not given unless class has had chemistry.)

Teacher to give a talk on the elements necessary for plant growth, and the three that are most likely to be deficient—nitrogen, potassium, phosphorus. (Experiments with Plants, pp. 137–140; Physics of Agriculture, pp. 69–71; Chemistry of Plant and Animal Life. Look up the necessary elements in the index.)

46 (3) Laboratory and Recitation. Fertilizers.

Materials.—Fertilizer samples, page 11.

Each pupil examine and describe the color, odor, and form of the different materials used in fertilizing. Put a little of each in water and see how readily it appears to dissolve. What is the source of each?

Find the approximate cost of the materials from which the complete fertilizers were made. Count nitrogen at 18 cents, phosphoric acid at $4\frac{1}{2}$ cents, potash at $4\frac{1}{2}$ cents a pound. Figure these on the smallest guaranteed per cent of nitrogen (N), phosphoric acid (P_2O_5) (available), and potash (K_2O). What is the price of the fertilizer? How much is therefore paid for mixing?

The New York State Experiment Station found that an average of $7.71 per ton was paid in that State for mixing fertilizer in 1904. Could a farmer mix these as cheaply? (New York Experiment Station Bulletin 225, pages 273, 274.)

What ones of the fertilizing materials and how much of each would be needed to give 40 pounds of nitrogen, 160 pounds of phosphoric acid, and 200 pounds of potash? How much would the total

weight be? Add enough filler (dirt) to this to make it weigh a ton,[a] and you have a fertilizer analyzing 2 per cent of nitrogen, 8 per cent phosphoric acid, and 10 per cent potash, i. e., a 2–8–10 fertilizer.

What materials and how much of each would be needed to make a fertilizer that would analyze 3–7–12?

At the Cornell Experiment Station 2 tons of manure that had been weighed and analyzed were left exposed from April 25 to September 22, with the following results:

	April 25.	September 22.
	Pounds.	*Pounds.*
Total weight	4,000	1,730
Nitrogen	19.60	7.72
Phosphoric acid	14.80	7.79
Potash	36	8.65

What was the value of the nitrogen, phosphoric acid, and potash on April 25 and on September 22? How much was lost? Notice that the humus is also a valuable part of the manure, and that much of it must have been lost. The decrease in weight was partly due to this loss. There are two ways to prevent most of these losses—the manure may be hauled and spread on the land every few days or it may be kept in a covered shed.

47 (3) Recitation. Commercial fertilizers as plant food.

(Give less time to this in regions where fertilizers are not used.)

Study and recite on Farmers' Bulletin 44.

48 (1) Recitation. Barnyard manure as plant food.

Study and recite on Farmers' Bulletin 192, pages 5–7, 21–25, and 30.

49 (2) Recitation. Fertilizer problems.

(Not to be given unless the class has studied chemistry. These are good problems for use in the chemistry class.)

I. Apply 40 pounds each of nitrogen, available phosphorus, and potassium to an acre of wheat with the following fertilizers:

1. Nitrate of soda ($NaNO_3=23+14+16_3$) 96 per cent purity.
2. Acid phosphate containing 16 per cent of available phosphoric acid ($P_2O_5=31_2+16_5$).
3. Muriate of potash (KCl=39.1+35.5) 80 per cent purity.

Answers:

1. $NaNO_3=23+14+16_3=85$.
   $14\div85=16.47$ per cent; 96 per cent of 16.47=15.81 per cent.

[a] Commercial fertilizers may be compounded without the use of fillers.

If in 100 pounds of nitrate of soda there is 15.81 pounds of nitrogen, it will require $40 \div 0.1581$ pounds to supply 40 pounds N or 253.0 pounds nitrate of soda.

2. $P_2O_5 = 31_2 + 16_5 = 142$.
   $62 \div 142 = 43.66$ per cent; 43.66 per cent of 16 per cent = 6.98 per cent.
   $40 \div 0.0698 = 573$ pounds acid phosphate.
3. $KCl = 39.1 + 35.5 = 74.6$.
   $39.1 \div 74.6 = 52.4$ per cent; 80 per cent of 52.4 per cent = 41.92 per cent.
   $40 \div 0.4192 = 95.4$ pounds muriate of potash.

II. Apply 40 pounds each of ammonia, available phosphoric acid, and potash to an acre of wheat, with the following fertilizers:

1. Nitrate of soda ($NaNO_3$) 96 per cent purity.
2. Acid phosphate containing available phosphoric acid equivalent to 35 per cent of bone phosphate of lime ($Ca_3P_2O_8$).
3. Muriate of potash (KCl) 80 per cent purity.

Answers:

1. $NaNO_3 = 23 + 14 + 16_3 = 85$, $NH_3 = 14 + 1_3 = 17$.
   $17 \div 85 = 20$ per cent; 96 per cent of 20 per cent = 19.2 per cent.

If in 100 pounds of nitrate of soda there is 19.2 per cent of ammonia it will require $40 \div 0.192$ to supply 40 pounds of ammonia or 208.3 pounds of nitrate of soda.

2. $Ca_3P_2O_8 = 40_3 + 31_2 + 16_8 = 310$.
   $P_2O_5 = 31_2 + 16_5 = 142$.
   $142 \div 310 = 45.8$ per cent; 45.8 per cent of 35 = 16.03 per cent.
   $40 \div 16.03 = 249.5$ pounds of acid phosphate.
3. $KCl = 39.1 + 35.5 + 74.6$; $K_2O = 39.1_2 + 16 + 94.1$.
   $\frac{94.1}{2} = 47.05$; $47.05 \div 74.6 = 63.1$; 80 per cent of 63.1 per cent = 50.5 per cent.
   $40 \div 0.505 = 79.2$ pounds of muriate of potash.

III. By a 2–8–4 fertilizer we mean one containing 2 per cent nitrogen (N), 8 per cent phosphoric acid (P_2O_5), 4 per cent potash (K_2O). Fertilizer agents often figure the nitrogen as ammonia (NH_3).

Assuming it is desired to apply to 20 acres the equivalent of 200 pounds per acre of a 5–8–2 fertilizer, determine:

1. How much of each of the following fertilizers would be required?

2. What would be the cost per ton of a 5–8–2 fertilizer based upon the cost of the ingredients in the separate fertilizers at the prices named?

3. How much less would the mixture made from the separate fertilizers weigh than if a 5–8–2 fertilizer was purchased?

1. Nitrate of soda 96 per cent pure, at $50 per ton.
2. Dissolved boneblack containing 14 per cent available phosphoric acid, at $15 per ton.
3. Muriate of potash, at $40 per ton.

Answers:

1. Ingredients required:

		N.	P_2O_5.	K_2O.	Cost.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	
Nitrate of soda	1,265	200	.....	.....	$31.62
Dissolved boneblack	2,285	.....	320	.....	17.14
Muriate of potash	158	.....	.....	80	3.16
	3,474	.....	.....	.....	51.92

2. 51.92÷2=$25.86 per ton.

3. 4,000—3,474=526 pounds.

50 (4) Laboratory. Identification of leguminous forage crops by means of their seeds and heads.

Materials.—Select and preserve the whole fruit (head) of a number of the leguminous forage plants and of those leguminous plants which are likely to occur as impurities or adulterants. The following are suggested: Red clover, alsike clover, alfalfa, black medic, sweet clover, hairy vetch. Study at least two of these—white and red clover will do if others can not be secured. The following outline suggests qualities which might be observed. Where adjectives used do not apply others may be used.

Calyx: No. of teeth ——; relative length of inferior tooth ——; persistent or easily removed.

Calyx tube: Hairy or smooth; No. of ribs.

Corolla: No. of petals ——; free or united; persistent or easily removed; smooth or hairy.

Pod: Roundish; kidney-shaped, elongated, straight, or twisted; opens longitudinally or transversely.

Style: Persistent or deciduous.

Seeds per pod: Extreme Nos. ——; usual No. ——.

Thrashing: Seeds easily removed or difficult to remove; reason.

Seed, viewed from two largest diameters: Round, oval, elliptical, or kidney-shaped.

Seed, viewed from two smallest diameters: Round, oval, or flat.

Seed: Length of largest diameter ——; second largest diameter ——.

Seed: Orange, yellowish-brown, yellow, reddish, red, green, yellowish-green, dark olive green, or black.

Hilum: Round, oval, or elongated.

Radicle: More than half the edge, half the edge, or less than half the edge.

Radicle: Tip prominent or not prominent.

53 (1) Recitation on No. 50.

54 (2) Laboratory. Purity of seed.

Materials.—Clover seed from several sources, hand lens. (Alfalfa or a grass seed may be used in place of clover.)

The clover seed may be secured from several sources. The prices of each sample should also be secured. One store may be able to furnish several lots; 4 ounces of each lot will be enough. Different pupils may work on different samples. It is well to have two independent results on each sample to serve as a check. Each pupil should compare his sample as follows:

Weigh out 3 grams of seed. Spread this on a sheet of paper. Use the lens in making the separation. Separate into three piles: (1) Chaff, dirt, broken seed, etc.; (2) weed seed; (3) clover seed. Weigh each lot. Save the clover seed from each sample for No. 55. Record results.

Sample.	By whom tested.	Weed seed, grams.	Chaff, dirt, broken seed, grams.	Clover seed, grams.	Per cent of clover seed.	Cost per bushel.	Cost per bushel, pure seed.

Which gives the largest amount of clover seed for the price? Does this sample contain many weed seeds? Considering price, quality, and weeds, which sample do you think should be purchased? Of what use is a fanning mill?

If the school has the set of seeds (page 10), each pupil should identify as many of the seeds as possible. Are there any seeds of bad weeds? Alfalfa or timothy may be used for this test if of more interest in the community. (Farmers' Bulletin 123, pages 3–6.)

55 (2) Demonstration or Laboratory. Germination test.

Materials.—Clover seed, separated out in No. 54 cotton flannel, two plates.

Moisten a piece of cotton flannel and lay it on a plate. Take 100 seeds from each sample of the pure clover seed just as they come. Put these on the cotton flannel, and label, so as to keep the different samples separate. Moisten another piece of cotton flannel and lay over them, and cover with an inverted plate. Keep the cloths moist, and keep in a moderately warm room. Examine from day to day, and count and remove the sprouted seeds from each sample.

Sample No.	Number germinated.			Total per cent germinated.
	3 days.	4 days.	5 days, etc.	
1.....				
2.....				
3.....				
4.....				

The quickness with which the seeds start indicates something of their vigor. Which sample germinated quickest? From this and No. 54 fill out the following table:

Sample No.	Cost per bushel.	Per cent of of good seed.	Cost per bushel of good seed.
1.....			
2.....			
3.....			
4.....			

Notice that the per cent of the good seed is the product of the per cent of pure seed in the sample multiplied by the per cent of this seed which germinated. If a sample contains 90 per cent of pure seed, and if 90 per cent of this seed germinates, the sample contains 81 per cent of good seed. (Farmers' Bulletins 260, page 6, and 218, page 18; Experiments with Plants, page 44.) In this way test seed for farmers of the neighborhood. If an offer to test seed is made, there is likely to be plenty of seed sent in. Seed corn should also be tested for farmers according to No. 60.

56 (2) Recitation. Good seed.

Pupils study and recite on Farmers' Bulletins 260, pages 3–8, and 111, pages 7–11 and 19–21. If preferred, this may be studied before No. 54.

57 (1) Recitation. Alfalfa seed.

If alfalfa is being grown in the neighborhood, study and recite on Farmers' Bulletin 194.

58 (4) Laboratory. Characters of the grain of corn.

Materials.—Ears of dent, flint, sweet, and pop corn, or as many of these as can be obtained.

Give each student from 25 to 30 grains each of the types of maize. For Nos. 3–5, a number of grains should be soaked in hot water for thirty minutes or in cold water for twenty-four hours. Study and describe each type according to the following outline:

Name of variety: ———. Date: ———.

1. Shape: Compare the shapes of kernels of each variety, also their surfaces.
2. Color: White, yellow, golden, red, or purple.
3. Place of color: Endosperm, aleurone layer, or hull.

4. Draw a cross section and indicate the endosperm, cotyledon, and plumule or radicle. If the section is made very close to the tip, the radicle will be seen instead of the plumule.
5. About what proportion of each variety is embryo? Horny starch? Soft starch? (Cereals in America, pages 151, 152.)

59 (1) Recitation on No. 58.

60 (2) Demonstration or Laboratory. Germination test of corn.

Materials.—Ten or more ears of corn.

Perform the test by the method given in Farmers' Bulletin 253, page 8.

61 (2) Recitation. Germination of seed corn.

Study and recite on Farmers' Bulletins 229 and 253.

62 (2) Demonstration. Depth to plant seeds.

Materials.—Box of soil. About 20 seeds each of peas, beans, clover, corn, wheat.

Plant two seeds of each kind at depths of ½, 1, 2, 3, 4, 5, 6 inches. Each kind may be planted in two duplicate rows. Record the date at which each comes up.

Depth.	Corn.	Wheat.	Clover.	Peas.	Beans.
One-half inch	Jan. 1				
One inch	Etc				
Etc					

What difference in the vigor of plants of the same kind planted at different depths? What depth was best for each? What relation between the size of seed and the desirable depth? Which would stand the deeper planting, peas or beans? A rule is sometimes given that those seeds which bring up the cotyledons should be covered by five times their thickness of soil and those which do not bring up their cotyledons by ten times their thickness. Why this difference? Of course the character of the soil, the temperature, and the amount of water are factors that influence the desirable depth to plant. What is the purpose of rolling or "planking?" Is it more desirable with small or with large seeds? In a wet or a dry season? See No. 37. (Farmers' Bulletin 218, page 17; Experiments with Plants, page 138.)

63 (4) Field Lesson or Laboratory. Leguminous forage plants.

Materials.—At least three of the following legumes: Red clover, alsike clover, alfalfa, black medic, sweet clover, hairy vetch, field peas.

This lesson is best conducted with fresh specimens, but dried specimens may be used. Study and describe as follows:

Leaves: Spirally arranged or two-rowed; abundant, medium, or not abundant; oval or elliptical; cordate or obcordate.

Leaflets: No. ———; palmate or pinnate; smooth or hairy; edges smooth or serrated.

Leaflets: Measure the length and width.

Midrib: Ending in leaflet, ending in tendril, or neither.

Stipules: Sketch; attached to petioles, not attached to petioles.

Stems: Round or square; hairy or smooth; stoloniferous or not stoloniferous.

Branches: None, few, or many.

Inflorescence: At the end of leaf-bearing stem or branch or springing from axil of leaf.

Inflorescence: Raceme, umbel, or capitulum.

Flowers upon maturity: Reflexed or not reflexed.

Calyx: Length of anterior tooth compared with other teeth.

Petals: United or free; white, red, pink, purple, blue, or yellow; persistent or not persistent.

(Definitions of any unfamiliar words may be looked up in a botany or dictionary.)

64 (1) Recitation on No. 63.

65 (4) Laboratory. Study of the vegetative portion of grasses in field.

Compare two different grasses according to the following outline:

Latin name, ———; common name, ———.

Where found, ———; date, ———.

Student's name, ———.

Leaf sheath: Round, elliptical or lenticular; smooth, downy, or rough; split to node, partly split, or entire; length, — inch to — inch.

Ligule: Long, medium, or short; acute pointed or obtuse pointed, truncate or rectangular; edges serrated or not serrated.

Leaf blade: Erect, ascending or drooping; smooth, downy, or rough; rolled or convolute in bud or folded or conduplicate in bud. State color, ———; length, — inch to — inch.

Midrib: Prominent, medium, or small.

End of blade: Acuminate, tapering, obtuse, or parallel sided.

(Compare redtop with Kentucky blue grass.)

Color of roots: White, brown, or red.

Lower internode: Normal or thickened.

Habit of growth: Intra-vaginal or extra-vaginal; no stolons, short stolons, or long stolons.

Diameter of single plant, — inch to — inch.

66 (3) Recitation. Pastures and meadows. (For humid regions.)
Study and recite on Farmers' Bulletin 66 and 227, pages 5–9.

67 (3) Recitation. Cattle ranges of the Southwest. (For arid regions.)
Study and recite on Farmers' Bulletin 72.

68 (2) Laboratory. Study of the spike of wheat.

Materials.—Heads of two or more varieties of wheat. The following are suggested: Dawson Golden Chaff, a soft white winter; Fultz, a red winter; Turkey, a hard winter; Fife, or blue stem, a hard spring; durum, a macaroni. The spikes of wheat should be laid between pieces of moistened blotting paper for several hours before handing to students, in order to toughen the parts.

Request each student to report the following, after examining a head of wheat:

1. Number of spikelets in the spike of wheat.
2. Number of flowers in each spikelet.
3. Number of grains in the whole spike.
4. Determine the number and arrange weight of grains occupying first, second, third, and fourth place from rachis.
5. Number of empty glumes in a spikelet.
6. Make a sketch of the beak, shoulder, and auricle of the empty glume.
7. How does the flowering glume differ from the palea?
8. How is the spikelet attached to the rachis?
9. Draw the rachis.

(Cereals in America, pages 31–33.)

69 (1) Recitation on No. 68.

70 (4) Laboratory. Study of the wheat grain.

Materials.—Grain of the varieties mentioned in No. 68, or other varieties. Compare at least two.

Description of kernels. Variety ———. No. ———.

1. Density: Very hard, hard, medium, soft, or very soft.
2. Appearance of cross-section: Very horny, horny, dull, or starchy.
3. Weight of 100 average seeds in duplicate: (*a*) ——; (*b*) ——.
4. Ratio of width to length (divide length of 25 seeds by width of 25 seeds with crease down).
5. Shape: Straight, oval, or pear-shaped.
6. Plumpness: Plump, medium, or shriveled.
7. Cheeks: Flat, plump, or angular.
8. At tip: Pointed or blunt.

9. At base: Pointed, blunt, or medium.
10. Crease: Deep, medium, or shallow; wide, medium, or narrow.
11. Brush: Large or small area; long or short hairs.
12. Color of kernels: Light yellow, yellow, clear amber, dull amber, clear red, or dull red.

(Cereals in America, pages 33, 34.)

71 (1) Recitation on No. 70.

Other recitations according to the outline on wheat should be given, or other crops may be studied.

72 (3) Recitation. Principles of bread making.

Study and recite on Farmers' Bulletin 112.

73 (4) Laboratory. The potato tuber.

Materials.—Potatoes, preferably of several varieties and some showing scab, dry rot, etc.

Study and describe according to the following outline:

Variety: Early, medium, or late.

Shape: Cylindrical, oval, or flat-oval; compound, regular, or irregular.

Size: Large, medium, or small; uniform or not uniform.

Eyes: Shape, deep, medium, or shallow; oval or narrow and elongated, large or small (as compared with size of tuber); numerous or few; uniformly distributed or mainly at bud end; ridge prominent or not prominent. Color, yellowish-white, pink, or russet. Sketch the tuber showing eyes, and indicate stem end of tuber.

Skin: Corky, netted, lenticeled, glossy-smooth, or dull-smooth. Color, yellowish-white, russet, red, pink, or blue; uniform or not uniform.

General characteristics: Sample clean or dirty; cracked or not cracked; disease present or absent; if present, scab, dry rot, blight; bruised or not bruised; green or not green.

Flesh: White, yellowish, pink, or blue.

Structure: Cortical layer thick or thin; dense or rare.

External medullary area: Uniform or not uniform; dense or rare.

Internal medullary area: Large or small.

74 (1) Recitation on No. 73.

75 (3) Recitation. Corn growing.

Study and recite on Farmers' Bulletin 199.

76 (3) Recitation. Alfalfa growing.

Study and recite on Farmers' Bulletin 215.

77 (4) Field Lesson. Cotton.

Materials.—Comb, tape measures, cotton that is mature.

Study according to the following outline:

Planting: Distance apart of rows, feet —, inches —; distance apart of plants, average of 10 plants, feet —, inches —. Ground, level or ridged; weedy or clean; compact or mellow.

Plants: Tall or short; wide, medium, or narrow; tap rooted or fibrous rooted; deep rooted or shallow rooted; internodes long or short; average length, — inches. Where do fruit branches grow out?

Leaves: Lobed or entire; pediceled or sessile; opposite or alternate; stipulate or not stipulate.

Bolls: Average length of ten, —; circumference of ten, —; long or short; large or small; pointing upward or downward.

Carpels: Heavy or thin; not rolled or rolled; blunt pointed or sharp pointed; average No., ———.

Lint: White, amber, or brown; ripe or unripe; abundant, medium, or scarce; clean or dirty; adherence strong, medium, or weak. Measure and get the average length of lint, —— inches. Comparative strength; weak, medium, or strong.

Seed: Large or small; fuzzy or smooth; if fuzzy, white or green; if smooth, black or brown; hilum at large end or small end. Comb out lint. Is it longest at the small end or large end of seed?

(C. P. Brooks, Cotton: Its Uses, Varieties; The Cotton Plant, Bulletin 33, Office of Experiment Stations, U. S. Department of Agriculture.)

78 (1) Recitation on No. 77.

79 (3) Field Lesson. Crossing cotton (for cotton-growing regions).

Materials.—Very small scissors, paper bags.

Take the class to a field of cotton. Select plants of the type which it is desired to cross which have a half dozen buds about to open and remove all other buds or flowers. The flowers on the plants to be used as female parent should be emasculated by carefully clipping away the petals and the inclosed stamens, care being taken that none of the anthers are broken, and the pollen dropped upon the stigma. Both the plants of the female and the male parents may be covered with paper bags. When the clefts of the stigma open, which is usually at or just before sunrise, dust upon them with pollen from a flower which has just opened on the plant to be used as the male parent. For convenience in handling the petals may be clipped off of the male flower.

80 (1) Recitation on No. 79, with particular reference to principles involved.

81 (3) Recitation. Improvement of cotton by selection. Study and recite on Separate No. 279, Yearbook 1902. Follow by a field practicum in selecting seed.

82 (3) Recitation. Insects affecting the cotton plant.

Read Farmers' Bulletins 47, 216, 223, and 290. Study one or more of the insects that are most important in the region. Have specimens of as many as possible.

83 (2) Recitation. Fertilizers for cotton.

Study and recite on Farmers' Bulletin 48.

84 (2) Recitation. Cotton growing.

Study and recite on Farmers' Bulletin 217.

85 (4) Laboratory. Judging cotton.

The following is the score card used by the Bureau of Plant Industry in judging hybrids between sea island and upland cotton. The teacher may prepare a similar card adapted to the cotton of the region and have students judge two or more samples.

Size of bolls (15 points)	Very large, 15 points. Large, 14 points. Medium, 12 points. Small, 8 points. Very small, 3 points.
Length of lint (20 points)	2 inches, 20 points. 1⅞ inches, 19 points. 1¾ inches, 18 points. 1⅝ inches, 17 points. 1½ inches, 15 points. 1⅜ inches, 10 points. 1¼ inches, 5 points.
Fineness of lint (10 points)	Very fine, 10 points. Fine, 8 points. Medium, 6 points. Coarse, 3 points.
Yield (20 points)	Excellent, 20 points. Good, 18 points. Medium, 15 points. Light medium, 10 points. Light, 5 points.
Uniformity in length of lint (7 points)	Excellent, 7 points. Good, 6 points. Fair, 4 points. Poor, 2 points.
Strength of lint (10 points)	Very strong, 10 points. Strong, 8 points. Medium, 8 points. Weak, 3 points.
Per cent of lint (18 points)	33 + per cent, 18 points. 31–32 per cent, 17 points. 29–30 per cent, 16 points. 27–28 per cent, 15 points. 25–26 per cent, 10 points. 23–24 per cent, 5 points.

86 (2) Laboratory. A home garden.

Make a drawing of a plan of a garden to supply your home with a succession of vegetables. The size of the family will, of course, be considered. Indicate the distance between rows, the vegetables to be planted in each row, etc. If the garden is to fit a certain piece of ground this space should be measured and mapped with the garden plan. Each pupil should be given a copy of Farmers' Bulletins 154 and 255.

On a farm it is important that the garden be arranged for convenience in horse cultivation. It is very desirable and profitable for farmers to grow a greater variety of vegetables than is now commonly grown.

It is very desirable that the teacher encourage the students to take up home industries for themselves. Gardens and poultry are the most available subjects.

87 (1) Recitation on No. 86.

88 (1) Laboratory. Order for seeds.

Make out an order for seeds for the above garden, ordering the right amount in each case. Catalogues enough to supply the class may be obtained from a seedsman.

89 (2) Laboratory. Propagation of plants.

Materials.—Stems of grape, currant, gooseberry, geranium, leaves of begonia.

Learn how to make the cuttings in each case. Some of these may be planted in a box in the schoolroom. Pupils may be encouraged to grow such cuttings at home. (Farmers' Bulletins 157 and 218.)

90 (2) Laboratory. Grafting and budding.

Each pupil to make several root grafts and buds. Root grafts of desirable apple trees may be made and taken home to be grown for the home orchard. Also encourage the grafting of trees at home. (Farmers' Bulletins 157 and 218.)

91 (2) Recitation. Propagation of plants.

Study and recite on Farmers' Bulletin 157.

92 (2) Recitation. Pruning.

Read Farmers' Bulletin 181. Recite on pages 7–10, 12–17, and 21.

93 (2) Field Lesson. Pruning.

Materials.—Saws and sharp jackknives.

Obtain permission to prune a few trees in some neglected orchard, or prune the trees in the school yard. Have students carry out the ideas gained in No. 92.

94 (2) Recitation. Tree planting.

Study and recite on Farmers' Bulletin 134.

95 (4) Recitation and Demonstration. Plant diseases.

Have pupils learn to recognize the plant diseases that are most important in the community. (Study at least one.) Call attention to how the fungi are propagated by spores and to the similarity to bread mold. Jar a puff ball and notice the cloud of dust. Each particle of this is a spore that could grow to be a puff ball under favorable conditions. If a microscopical study of some fungus disease has not been made in botany, such a study should be made in agriculture.

96 (4) Recitation and Demonstration. Insect enemies of plants.

Similarly examine and learn to recognize the insect enemies that are of most importance in the community. (Study at least one.) What are the different stages in the life of each? Which ones chew their food and which ones suck it? If no instruction on insects has been given, more time should be devoted to the topic here.

97 (2) Demonstration or Laboratory. How to prepare Bordeaux mixture.

Materials.—Copper sulphate, unslaked stone lime, potassium ferrocyanid, balances, two fruit jars, quart size, and several 2-quart size.

Bordeaux mixture is made by pouring together dilute solutions of copper sulphate and lime. Various formulas may be used. Five pounds of copper sulphate and 5 pounds of stone lime to 50 gallons of water is a good standard formula. The amount of copper may be varied from 2 to 6 pounds for 50 gallons, and enough lime is always used to more than neutralize the copper sulphate.

Into a 4-ounce bottle of water put about $\frac{2}{3}$ ounce, or 12 grams, of potassium ferrocyanid. Label "Poison."

Prepare a stock solution of copper sulphate by dissolving bluestone at the rate of 1 pound to a gallon—say, 8 ounces to a 2-quart jar.

Prepare a stock solution of lime in the same manner by slaking $\frac{1}{2}$ pound of lime and stirring it up in a 2-quart jar of water.

To make Bordeaux mixture properly, put into one of the quart jars 6 fluid ounces of the stock solution of copper sulphate and dilute it with water to fill the jar. Into the other jar put 6 ounces of the stock lime solution after stirring it to secure uniformity. Dilute in the same manner and stir the dilute solution. Pour the two together simultaneously into a 2-quart jar. Stir slightly and observe the bright sky-blue color of the resulting precipitate.

Add a drop or two of potassium ferrocyanid to this mixture. If there is enough lime to neutralize the copper sulphate the potassium ferrocyanid will retain its yellow color: if not, it will become bright red brown. Set the jar aside and mark or note the time.

For comparison with the above make Bordeaux mixture as follows: Pour 6 fluid ounces of stock-copper solution directly into the 2-quart jar, then add the 6 ounces of stock-lime solution (eliminating the dilution jars) and pour in water sufficient to fill the jar. Stir this mixture slightly, place it beside the first, and note the difference. In which does the precipitate settle quicker? What is its color?

Make another mixture. Pour 6 ounces of bluestone solution into one of the quart jars and dilute with water to fill the jar. Into the other jar put 6 ounces of the stock lime and dilute to fill the jar. Pour into a 2-quart jar simultaneously as before, but withhold three-fourths of the lime milk. After stirring slightly observe the greenish color of the mixture. Then add a drop of potassium ferrocyanid and note the bright red-brown color as the yellow liquid strikes the mixture. Add a little more lime milk and test again until just enough lime has been added to neutralize the copper. About what proportion remains in the original dilution jar? Compare the color of the neutral Bordeaux with the color of the other mixtures.

Make various mixtures of bluestone and lime. Dilute first one stock solution and then the other; add the lime to the bluestone and then the bluestone to the lime, and compare these with the Bordeaux mixture made according to the first directions. (Farmers' Bulletin 243.)

98 (1) Recitation on No. 97.

99 (1) Recitation or Demonstration. Preparation of the lime, sulphur, and salt spray.

To be given in regions where the San José scale is present. Read Farmers' Bulletin 227, pages 19–22: Circular 52, Bureau of Entomology; and article by A. L. Quaintance reprinted from the Yearbook for 1906, entitled "Lime-Sulphur Washes for the San José Scale."

100 (3) Recitation. How insects affect the health in rural districts.

Study and recite on Farmers' Bulletin 155. This might be studied in the physiology class.

101 (2) Laboratory. Bacteria.

Materials.—Compound microscope, milk.

Examine a little milk under a microscope (×500). Make a drawing showing bacteria and fat globules. How many different shapes of bacteria can you see?

102 (2) Demonstration or Laboratory. Bacteria and molds.

Materials.—Three test tubes, cotton, boiled potato or fruit (apple sauce is good); three apples, one partly decayed.

(*a*) Fill each tube about one-third full of apple sauce. Plug each one with cotton. Set one aside. Put the other two into a pail of water and boil for half an hour. After boiling set one tube aside

with the cotton undisturbed. Take the cotton from the third tube and leave it out for half an hour or more, then put it in again. Leave these for a few days and see what happens. It is probable that the one that was heated and kept closed will keep, but that the others will be spoiled. Account for the difference. Is it desirable to leave canned fruit open a few minutes before covering after cooking? Why?

(*b*) Prick one of the sound apples in several places with a pin. Put the pin into the rotten apple and then into the other sound apple. Repeat this in several places. Set the two sound apples aside for about a week. What happens? It is probable that the second one will show decay where "inoculated" from the rotting apple. Account for the differences. What is one value of the skin to an apple?

103 (1) Recitation. Bacteria and molds.

Study and recite on Farmers' Bulletin 203, pages 3–9.

Explain sour bread, the formation of cider, and vinegar. Bacteria and molds require heat and moisture for development. There are corresponding ways of preserving. Preservatives which kill bacteria may also be used. Some of these are harmful, but some are not. Notice dried meat, salt meat, ice box. Salt is sometimes used on hay. What principle is used in preserving silage?

104 (2) Field Lesson. Farm forestry.

Visit the woods on a farm. What trees have the method of cutting favored? What are the leading kinds and what proportion of each? Learn the names of the common trees. Much of the cutting in woods is done in such a way as to leave the undesirable trees—the tree weeds.

105 (2) Recitation. Forestry.

Read Farmers' Bulletin 173.

106 (2) Recitation. Relation of forests to stream flow.

Study and recite on Separate 329 from the Yearbook for 1903.

107 (3) Recitation. Farm problems.

Give some practice in computing the capacity of bins, cribs, amount of hay in a mow or stack, computing land areas, etc.

108 Field Lesson. Farm problems.

If possible arrange to have each student raise some crop during the summer. Keep an accurate record of all work done, time required, yields, total cost of labor and other expenses, and total receipts.

109 (3) Recitation. Farm buildings.

Study and recite on Farmers' Bulletin 126.

110 (3) Recitation. Modern conveniences for the farm home.

Study and recite on Farmers' Bulletin 270.

111 (3) Recitation. Earth roads.

Study and recite on Farmers' Bulletin 136.

112 (2) Field Lesson. Agricultural manufacturing.

Visit a flour mill, creamery, vinegar factory, evaporator, canning factory, grape-juice factory, or other similar industry. Study the different operations and connect them with the scientific principles involved.

113 (1) Recitation. Government work in agriculture.

Where is your State experiment station located? Your State agricultural college? What is the general character of the work done by each and by the United States Department of Agriculture? What publications are available from each and how secured?

A. C. True,
T. F. Hunt,
H. T. French,
H. C. White,
J. F. Duggar,
W. E. Stone,
Committee.

Recommended for publication.
A. C. True, *Director.*

Publication authorized.
James Wilson,
Secretary of Agriculture.

Washington, D. C., *October 17, 1907.*

[Cir. 77]

O